554. **INVESTIGATION OF MOISTURE-INDUCED EMBRITTLEMENT OF IRON ALUMINIDES**
$73,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Rensselaer Polytechnic Institute Contact: N. S. Stoloff, (518) 276-6371

The purpose of this work is to study hydrogen embrittlement of iron aluminide alloys. Moisture in air can significantly reduce the room-temperature tensile ductility of Fe_3Al-based alloys by combining with the aluminum in the alloys to form atomic hydrogen. The atomic hydrogen diffuses rapidly into the material causing embrittlement. Experiments are being conducted on selected Fe_3Al alloys that will lead to an understanding of the phenomenon. The work focuses on the effects of moisture on relevant mechanical properties such as fatigue and tensile strengths, and correlates important microstructural variables such as degree of order, grain size, and phases present with the alloy's susceptibility to embrittlement.

Keywords: Aluminides, Embrittlement, Moisture

555. **CORROSION PROTECTION OF ULTRAHIGH TEMPERATURE INTERMETALLIC ALLOYS**
$146,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: P. F. Tortorelli, (423) 574-5119

The objective of this task is to develop high-strength, corrosion-resistant intermetallic alloys for use as hot components in advanced fossil energy conversion and combustion systems. The successful development of these alloys is expected to improve the thermal efficiency of fossil energy conversion systems through increased operating temperatures and to increase the service life of hot components exposed to corrosive environments at elevated temperatures (1000°C). The initial effort will be devoted to in situ composite alloys based on the $Cr\text{-}Cr_2Nb$ system.

Keywords: Corrosion, Chromium-Niobium, Mixed-Gas, Scales

556. **OXIDE DISPERSION STRENGTHENED (ODS) IRON ALUMINIDE EQUIPMENT**
$35,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: I. G. Wright, (423) 574-4451

This task provides funds for the procurement of major equipment items necessary for AR&TD Materials Program activities.

Keywords: Equipment

557. **OXIDE DISPERSION STRENGTHENED (ODS) IRON ALUMINIDES**
$222,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: I. G. Wright, (423) 574-4451

The purpose of this task is to develop fabrication procedures for making oxide dispersion-strengthened (ODS) iron-aluminum alloys based on Fe_3Al. The suitability of the procedures is measured in terms of the high-temperature oxidation and sulfidation resistance and creep strength of the ODS alloys compared with Fe_3Al alloys fabricated by conventional ingot and powder processes.

Keywords: Aluminides

558. **MATERIALS SUPPORT FOR HITAF**
$0 (PYF)*
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: K. Breder, (423) 574-5089

This task involves the measurement of selected mechanical and physical properties of structural ceramics which are proposed for use in the construction of the High Temperature Advanced Furnace (HITAF) air heater design being developed under the Combustion 2000 program for PETC/DOE. The purpose of the research is to evaluate candidate structural ceramics for this application by studying the fast fracture and fatigue (both dynamic and interrupted static) properties at temperatures from 1100 to 1400°C in air, their corrosion behavior, property uniformity of components and long term degradation of ceramic properties due to exposure in prototype HITAF systems.

*PYF denotes that funding for this activity, active in FY 1995, was provided from prior year funds.

This work is continuing with funding from the Combustion 2000 Program.

Keywords: Furnace, Materials, HITAF

559. **CHARACTERIZATION OF LOW-EXPANSION CERAMIC MATERIALS AND DEVELOPMENT OF SOL GEL-DERIVED COATINGS AS INTERFACES FOR SIC COMPOSITES**
$23,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
University of Tennessee Contact: Peter Liaw, (423) 974-6356

The purpose of this activity is the experimental study of low-expansion ceramic materials and the development of sol-gel derived coatings as interfaces for Nicalon®/SiC composites

Keywords: Composites, Ceramics

560. **JOINING OF CERAMICS**
$50,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Idaho National Engineering Laboratory Contact: B. H. Rabin, (208) 526-0058

The purpose of this project is to explore and develop joining techniques for silicon carbide fiber-reinforced silicon carbide ceramics produced by chemical vapor infiltration and deposition (CVID). The research goals include identifying appropriate joining methods, establishing experimental procedures for fabricating joints, and characterizing the structure and properties of joined materials. An understanding of the factors that control joint performance is sought through studies of the relationships among processing variables, joint microstructures, and mechanical properties. Additional funds for this project are provided by the DOE Pittsburgh Energy Technology Center.

Keywords: Ceramics, Joining, Technology Transfer

561. **SUPPORT SERVICES FOR CERAMIC FIBER-CERAMIC MATRIX COMPOSITES**
$25,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
University of North Dakota Energy and Environmental Research Center Contact: J. P. Hurley, (701) 777-5159

This task will review and, if appropriate, propose modifications to plans, materials, and tests planned by researchers on the AR&TD Materials Program in work to test materials for coal-fueled energy systems. The changes shall be suggested in order to make the corrosion experiments more reflective of the actual conditions that will be encountered by the materials in the energy systems. UNDEERC shall accomplish this task by reviewing the major advanced energy system projects being funded by the DOE, and by working with the company's technical monitor and staff to prepare a summary of the expected corrosion problems. Both gasification and combustion systems will be included. Ceramic materials in two subsystems will be the focus of this work: (1) hot gas cleanup systems and (2) high-temperature heat exchangers. UNDEERC shall review and suggest improvements to materials testing procedures that are used to determine material behavior when used in hot-gas cleanup or heat exchanger applications. A limited amount of computer modeling and laboratory experimentation shall be a part of this effort.

Keywords: Composites, Ceramics, Fibers

562. **DEVELOPMENT OF NONDESTRUCTIVE EVALUATION METHODS AND EFFECTS OF FLAWS ON THE FRACTURE BEHAVIOR OF STRUCTURAL CERAMICS**
$310,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Argonne National Laboratory Contacts: W. A. Ellingson, (708) 252-5068 and J. P. Singh, (708) 252-5123

The purpose of this project is to study and develop acoustic and radiographic techniques and possible novel techniques such as nuclear magnetic resonance, to characterize structural ceramics with regard to presence of porosity, cracking, inclusions, amount of free silicon, and mechanical properties, and to establish the type and character of flaws that can be found by nondestructive evaluation (NDE) techniques. Both fired and unfired

specimens are being studied to establish correlations between NDE results and failure of specimens.

Keywords: Nondestructive Evaluation, Ceramics, Flaws, Fracture

563. **FRACTURE BEHAVIOR OF ADVANCED CERAMIC HOT-GAS FILTERS**
$125,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Argonne National Laboratory Contacts: J. P. Singh, (708) 252-5123

The purpose of this project is to study the fracture behavior of ceramic hot-gas filters. ANL shall evaluate mechanical/physical properties and microstructure, identify critical flaws and failure modes, and correlate mechanical/physical properties with microstructure and critical flaws to provide much needed information for selection of materials and optimization of fabrication procedures for hot-gas ceramic filter modules. As part of the information base, requirements for strength and fracture toughness of the filter material shall be established from stress and fracture mechanics analyses of typical filters subjected to loadings expected during operation and pulse-cleaning cycles.

Keywords: Ceramics, Flaws, Fracture, Failure

564. **CERAMIC CATALYST MATERIALS**
$225,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Sandia National Laboratories Contact: A. G. Sault, (505) 844-8723

The purpose of this research is to investigate the role of ceramic material properties in the catalytic activity of a novel class of catalytic supports, known as hydrous titanium oxides (HTO). Catalysts prepared on these materials show particular promise as economically and environmentally attractive alternatives to present commercial catalysts for the direct liquefaction of coal. In these studies, improved understanding and control of the synthesis process is being pursued in order to tailor the composition, molecular structure, microporosity, and physical/mechanical properties of the HTO thin films. The effects of altered structure, composition, and other material properties of the thin film ceramic support material on catalytic activity are being assessed.

Keywords: Ceramics, Catalysts

DEVICE OR COMPONENT FABRICATION, BEHAVIOR OR TESTING

565. ***MATERIALS AND COMPONENTS IN FOSSIL ENERGY APPLICATIONS* NEWSLETTER**
$60,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: I. G. Wright, (423) 574-4451

The purpose of this task is to publish a periodic (bimonthly) DOE-EPRI newsletter to address current developments in materials and components in fossil energy applications. Equal funding is provided by EPRI.

Keywords: Materials, Components

566. **CERAMIC FIBER FILTER TECHNOLOGY**
$50,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: M. A. Janney, (614) 424-4281

The purpose of this effort is to develop the fabrication technology necessary to make ceramic-fiber based filters for a variety of filtration applications of interest to the Fossil Energy community.

Keywords: Filters, Ceramics, Fibers

567. **FABRICATION OF FULL-SCALE FIBER-REINFORCED HOT-GAS FILTERS BY CHEMICAL VAPOR DEPOSITION**
$0 (PYF)*
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
3M Company Contact: M. A. Leitheiser, (612) 733-9394

The purpose of this project is to scale-up the chemical vapor infiltration and deposition (CVID) process developed at Oak Ridge National Laboratory for fabricating ceramic

*PYF denotes that funding for this activity, active in FY 1995, was provided from prior year funds.

fiber-ceramic matrix composites. The goal is to use the scaled-up CVID process to produce composite filters that have the requisite strength and toughness, but which also have sufficient porosity to be permeable to gas streams and the appropriate size and distribution of porosity to be an effective filter. A practical process for fabricating porous ceramic fiber-ceramic matrix candle filters (full-size) with increased surface area has been developed.

Keywords: Ceramics, Composites, Filters

568. **DEVELOPMENT OF CERAMIC MEMBRANES FOR GAS SEPARATION**
$400,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Oak Ridge K-25 Site Contact: D. E. Fain, (423) 574-9932

The purpose of this activity is to fabricate inorganic membranes for the separation of gases at high temperatures and/or in hostile environments, typically encountered in fossil energy conversion processes such as coal gasification. This work is performed in conjunction with a separate research activity that is concerned with the development and testing of the ceramic membranes.

Keywords: Ceramics, Membranes, Filters, Separation

569. **CORROSION PROTECTION OF CERAMIC HEAT EXCHANGER TUBES**
$125,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Pennsylvania State University Contact: R. E. Tressler, (814) 865-7961

This project addresses the development of ceramic heat exchanger materials with chromia surface treatments for corrosion resistance. High chromia-content refractories have been demonstrated to be resistant to corrosion by coal slags. This project will focus on improving the corrosion resistance of ceramics by incorporating chromia into the surface layers.

Keywords: Ceramics, Corrosion, Filters

570. **INVESTIGATION OF THE MECHANICAL PROPERTIES AND PERFORMANCE OF CERAMIC COMPOSITE COMPONENTS**
$150,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Virginia Polytechnic Institute Contact: K. L. Reifsnider, (703) 231-5259

The purpose of this project is to develop a test system and test methods to obtain information on the properties and performance of ceramic composite materials. The work involves a comprehensive mechanical characterization of composite engineering components such as tubes, plates, shells, and beams subjected to static and cyclic multiaxial loading at elevated temperatures for extended time periods.

Keywords: Ceramics, Composites, Mechanical Properties, Testing

571. **STABILITY OF SOLID OXIDE FUEL CELL (SOFC) MATERIALS**
$250,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Pacific Northwest Laboratory Contact: L. R. Pederson, (509) 375-2579

The purpose of this task is to evaluate the chemical and physical stability of fuel cell materials and interfaces under conditions relevant to an operating SOFC and to identify features in SOFC operation that would limit system performance.

Keywords: Fuel Cells, SOFC

572. **MIXED OXYGEN ION/ELECTRON-CONDUCTING CERAMICS FOR OXYGEN SEPARATION AND FUEL CELLS**
$225,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Pacific Northwest Laboratory Contact: L. R. Pederson, (509) 375-2579

The purpose of this task is to develop ceramic compositions and physical forms that will provide the highest

possible oxygen separation efficiencies from air at the lowest cost.

Keywords: Fuel Cells, Electrochemical, Electrolytes

573. **PROTON-CONDUCTING CERATE CERAMICS**
$225,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Pacific Northwest Laboratory Contact: L. R. Pederson, (509) 375-2579

The purpose of this task is to develop cerate perovskites for use as hydrogen separation membranes, as hydrogen sensors, in membrane reactors, and in gas cleanup.

Keywords: Fuel Cells, Electrochemical, Electrolytes

574. **ODS Fe_3Al TUBES FOR HIGH-TEMPERATURE HEAT EXCHANGERS**
$53,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
PM Hochtemperatur-Metall. GmbH Contact: Dieter Sporer, 011-43-5672-70-2923

The goal of the work is to produce tubes of Fe_3Al-0.5 wt. percent Y_2O_3 which have properties suitable for application as heat transfer surfaces in very high-temperature heat exchangers. The alloy is produced by a powder metallurgical (mechanical alloying) process, the main purpose of which is to obtain a uniform distribution of sub-micron Y_2O_3 particles in the Fe_3Al matrix. The required high-temperature creep strength is derived largely by developing very large, elongated grains which are effectively pinned by the oxide dispersion. Development of the necessary grain structure is dependent on the characteristics of the mechanically-alloyed powder, and on thermomechanical processing of the consolidated powder.

Keywords: Aluminide, Tubes, Heat Exchangers

575. **POROUS IRON ALUMINIDE ALLOYS**
$23,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Oak Ridge K-25 Site Contact: D. E. Fain, (423) 574-9932

This project is directed to the development of porous iron aluminide structures for applications such as hot-gas filters

Keywords: Filters, Aluminides

576. **IRON ALUMINIDE FILTERS**
$50,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: P. F. Tortorelli, (423) 574-5119

The purpose of this project is to provide technical support to the Pall Corporation in its development of porous sintered iron-aluminide filters for hot-particle removal from product streams in coal gasification systems. The ORNL role is to provide specialized expertise in the areas of corrosion analysis, microstructural characterization, alloy selection, and processing based on extensive experience with iron aluminides and materials performance in fossil energy systems. ORNL's contribution via this project should aid the success and timely completion of Pall's development and demonstration efforts.

Keywords: Filters, Aluminides

577. **EVALUATION OF CERAMIC HEAT EXCHANGER TUBES AND JOINTS**
$158,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Pennsylvania State University Contact: R. E. Tressler, (814) 865-7961

This project has two principal parts: (1) screening analysis of candidate ceramic hot-gas filter materials, and

(2) development of ceramic heat exchanger materials with chromium surface treatments for corrosion resistance. A flow-through screening test will be developed to test ceramic hot-gas filter elements in simulated coal combustion environments. Corrosion-resistant heat exchanger tubes will be fabricated by incorporating chromium in the surface layers.

Keywords: Ceramics, Corrosion, Filters

578. **THERMAL AND MECHANICAL ANALYSIS OF A CERAMIC TUBESHEET**
$40,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824
Mallett Technology Contact: R. H. Mallett, (919) 406-1500

A transport combustor is being commissioned at the Southern Services facility in Wilsonville, Alabama, to provide a gaseous product for the assessment of hot-gas filtering systems. These hot-gas filtration systems will include granular-bed and barrier filter concepts. Filters will be evaluated for carbonizer and gasifier gaseous products. In addition, a pressurized fluidized-bed combustor (PFBC) will be installed to burn the carbonizer product, and a hot gas filter will be installed in the PFBC gas stream. Compositions of the gas streams will range from oxidizing to reducing, and the partial pressures of oxygen and sulfur will vary substantially. Temperatures of the gas streams will range from 840 to 980°C (or higher). One of the barrier filters under consideration incorporates a ceramic tubesheet to support the candle filters. This system, to be designed and built by Industrial Filter & Pump Manufacturing Company (IF&PM) is unique and may offer distinct advantages over metal/ceramic systems that have been tested extensively in other EPRI/DOE projects. To gain an insight that could prove to be useful in the scaleup of a commercial-size, all-ceramic system, work will be undertaken to develop a design methodology applicable to the thermal-mechanical analysis of the all-ceramic system.

Keywords: Ceramics, Tubesheet

579. **CERAMIC TUBESHEET DESIGN ANALYSIS**
$10,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: R. W. Swindeman, (423) 574-5108

The purpose of this task is to perform thermal and mechanical analyses of critical regions in a ceramic tubesheet support for barrier filters in a hot gas cleanup vessel designed for use in gasifier, carbonizer, and pressurized fluidized bed combustion gas streams.

Keywords: Ceramics, Tubesheet

INSTRUMENTATION AND FACILITIES

580. **MANAGEMENT OF THE FOSSIL ENERGY AR&TD MATERIALS PROGRAM**
$400,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824

The overall objective of the Fossil Energy Advanced Research and Technology Development (AR&TD) Materials program is to conduct a fundamental, long-range research and development program that addresses, in a generic way, the materials needs of fossil energy systems and ensures the development of advanced materials and processing techniques. The purpose of this task is to manage the Fossil Energy AR&TD Materials program in accordance with procedures described in the Program Management Plan approved by DOE. This task is responsible for preparing the technical program implementation plan for DOE approval; submitting budget proposals for the program; recommending work to be accomplished by subcontractors, other national laboratories, and by Oak Ridge National Laboratory (ORNL); placing and managing subcontracts for fossil energy materials development at industrial research centers, universities, and other government laboratories; and for reporting the progress of the program.

Keywords: Management, Materials Program

581. **GENERAL TECHNOLOGY TRANSFER ACTIVITIES**
$35,000
DOE Contacts: J. P. Carr, (301) 903-6519 and E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole, (423) 574-4824

The task provides funds for the initiation of technology transfer activities to identify and develop relationships with industrial partners for the transfer of AR&TD Materials Program technologies to industry.

Keywords: Technology Transfer

582. **GORDON RESEARCH CONFERENCE SUPPORT**
$4,000
DOE Contacts: J. P. Carr, (301) 903-6519 and
E. E. Hoffman, (423) 576-0735
Oak Ridge National Laboratory Contact: N. C. Cole,
(423) 574-4824

The task provides funds to support the annual Gordon Research Conference.

Keywords: Technology Transfer